Physics 107
Laboratory Manual
Fall 2017

College of
William and Mary
Physics Department

http://physics.wm.edu/~labs/

Laboratory Manual: Physics for Life Sciences 107

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Physics 107 Laboratory Schedule for Fall 2017

No.	**Lab Name**	**Week**
*	**No Lab** Partial Week	August 30 - September 1
1	Introduction	September 4-8
2	Vectors	September 11-15
3	Kinematics - Velocity and Acceleration	September 18-22
4	Newton's 2^{nd} Law	September 25-29
5	Uniform Circular Motion and Centripetal Force	October 2-6
6	Energy	October 9-13
*	**No Lab** Fall Break	October 16-20
7	Momentum and Collisions	October 23-27
8	Rotational Motion	October 30 - November 3
9	Simple Harmonic Motion	November 6-10
10	Wave Phenomena	November 13-17
*	**No Lab** Thanksgiving	November 21-25
11	Blood Pressure	November 27 - December 1
*	**No Lab** Last Week of Class	December 2-4

Introduction

Without exception, all fields of science rely on experimental data to test theoretical models of the world around us. To fully understand the concepts of physics and other sciences, it is not sufficient to learn from a textbook alone. By performing hands-on experiments, you are able to explore and confirm the concepts which scientists have put forth to describe the processes that govern our universe. In addition, you gain the ability to conduct independent scientific research.

To earn a successful grade for your lab each week, you must successfully complete all steps of the experiment and write a lab report that presents the experiment, data, analysis,and error analysis in a clear and concise manner. In addition, you must correctly answer all of the questions in the lab manual and any additional ones posed by your TA. Poorly executed experiments, poorly written reports (this includes the scientific quality as well as grammar and neatness), failure to clearly analyze experimental errors, incorrect answers to questions, unlabeled graphs, and unitless numbers will result in a poor grade. A successful experimentalist is one who understands the scientific goals and principles behind the experiment, pays clear attention to the details and potential errors, and presents the results in a clear and accurate report.

General Policy

In order to provide for consistency in policy and grading practices across the various sections of the introductory physics labs, the Department of Physics has adopted the following guidelines. Questions concerning these policies should be directed to your teaching assistant (TA) or the lab director.

Eating, drinking, or smoking in the lab room is not allowed. Even the most careful and considerate students run the risk of damaging equipment if a liquid should accidentally be spilled. There is also the possibility of injury from such accidents with the electronic equipment used in some labs.

Students must bring their laboratory manual or a copy of the current experiment to class. In addition, each student should bring paper, pencils, and a scientific calculator. A protractor, your textbook, a ruler with centimeter scale, and a flash memory stick are often useful. The lab manual is also available as PDF files from the introductory lab web page. The URL of the lab web page is:

http://physics.wm.edu/~labs/

Laptop Computers and Software

Williams and Mary students are expected to have a laptop computer. You should always bring your laptop to each meeting of your lab section. The physics department has purchased a site license for the software (Pasco's Capstone) which will be use for several of the experiments during the semester. The first meeting of your lab section will be devoted to installing the Capstone software, verifying it is correctly installed and learning to use the basic features. This software will be used repeatedly throughout the semester.

Attendance

In general, the only acceptable excuse for missing a lab is an emergency or serious illness. Whenever possible you should contact your TA prior to missing a lab. A note from the office of the Dean of Students may be required to excuse the absence. Because each experiment requires specialized equipment which is only set up for one week, it is difficult to make-up missed labs. Also, because there are not enough experimental set-ups to accommodate an overfilled class, it is not possible for students to attend a lab section for which they are not registered unless approved by the lab director and your teaching assistant. Even with the approval of the lab director or your teaching assistant, a make-up lab can only be done during the week the lab is scheduled. For these reasons, it is important that you make sure you are registered for a lab section that you will be able to attend for the entire semester.

Students must attend the lab section for which they registered. Requests to change lab sections after the beginning of the semester will only be allowed under exceptional circumstances.

An unexcused absence from a scheduled laboratory will result in a student receiving a grade of zero (0) for that lab.

A student who presents documentation indicating that their absence from a lab should be excused will be considered on a case-by-case bases. Normally, a maximum of two (2) excused absences will be considered. The definition of an excused absence shall be an absence for which the Dean of Students is willing to offer a written excuse. Excused absences are normally limited to (1) illness with a written doctor's statement, (2) a major illness, death or other emergency in the immediate family, or (3) official William and Mary business.

Grading

The lowest lab grade for the semester will be dropped from the student's final lab average. However, only regular 'in class' labs will be considered for the dropped lab. The three labs where a formal lab report is required will only be dropped for an excused absence with a written excuse from the Dean of Students.

To ensure fairness and uniformity across lab sections, all labs sections will be graded on the same scale. The first lab of the semester (Introduction) will count 10 points. The two formal lab reports during the semester will count 30 points. All other 'in class' labs will count 20 points. Except for the first lab which does not require a prelab, all 'in class' labs will require a prelab.

Unless there are unusual circumstances, letter grades will be assigned based on the the ususal scale of:

A	93% - 100%
A-	90% - 92.99%
B+	87% - 89.99%
B	83% - 86.99%
B-	80% - 82.99%
etc.	

Lab Quiz

A short quiz will be given before each lab to ensure the student is prepared for the lab. The quiz will count four (4) points.

The quiz is intended to make the student study and understand the lab to be performed. The quiz will be given at the start of each lab period. **The first lab of the semester will not have a quiz.** Your teaching assistant for the lab will explain the quiz in detail at the first lab meeting.

Without reading and understanding the lab before coming to lab class, you cannot hope to complete the lab in the required time and make sense of the data. Putting the required time into reading the lab manual before class will make your lab experience a more enjoyable learning experience.

Lab Reports

Lab reports consist of three different types:

- Introductory (first) lab. This lab will count 10 points. No prelab is required for this lab. This lab will be mainly devoted to meeting your TA, installing software (Capstone) and making a few simple measurements of position and velocity. **There will not be a quiz, and a prelab is not required for the first lab.**
- 'In class' labs. 'In class' lab reports each count 20 points. The majority of the labs during the semester will be 'in class' labs. You will complete the experiment in class and submit the report to your TA at the end of the class period. Each 'in class' lab **requires a prelab**.
- Formal labs. Two labs during the semester will require a formal lab report. The formal lab reports each count 30 points. The formal lab reports will be on the experiments covering 'Kinematics - Velocity and Acceleration' and 'Rotational Motion'.

Guidelines for 'In Class' Lab Reports

'In class' labs will consist of the student writing a prelab before coming to class, performing the experiment, analyzing the data, and writing the conclusion during the class period. 'In class' labs will be submitted to the TA at the end of the class period. 'In class' lab reports must be the work of the individual student except for data collected during the lab period. Group reports are not allowed.

The 20 points for the 'in class' lab reports will be allocated as follows:

- Quiz - 4
- Prelab - 3 points
- Data Procedure - 8 points
- Conclusion - 5 points

Prelab: For each 'in class' lab, you must prepare a **prelab**. To familiarize students with the nomenclature, equipment, and procedures for each lab, students are required to submit a 250 to 350 words summary (prelab) of the lab to be performed. Prelabs must be completed before coming to class. The prelab must be typed. The prelab can not be copied from the lab manual but must be the work of the individual student. All important concepts, physical principles, and laws should be clearly explained. Theoretical information should be clearly explained and its relevance to the experiment clearly defined. In addition, be sure to include your name, your TA's name, and the course and section number. The prelab summary will form the introduction to your lab report.

Data Procedure and Analysis: The lab manual has detailed instructions for performing the experiment. As you go through the experiment, you will record data values individually or in tables. You will be ask to do calculations and make graphs. Questions will be asked which you should answer in the provided space. While it is normally not necessary, you may use additional sheets of paper if more space is required. Additional sheets should be clearly labeled and referenced.

Conclusion: The conclusion is where you state whether or not you confirmed the principle being tested and present a thorough description of any relevant errors. Was the objective stated in the purpose section attained? If a physical parameter was measured, what is the value? How does the value compare to the accepted value? What is the 'uncertainty' in your value, e.g., percent error? You can use additional paper if the space provided in the manual is insufficient.

Guidelines for Formal Lab Reports

The responsibility of an experimental scientist is to accurately report the results of the experiment. Good scientific writing skills are as important to a scientist as the writing skills of a journalist or poet are to their professions. A good lab report will always have certain qualities that make it useful to outside readers. First, the report should be written in such a way that a non-expert (someone not in your lab class) could read it. It should clearly state: what principles you were trying to test, how you did the measurement, what data you obtained, whether or not you confirmed the theoretical prediction, and what errors were associated with the measurement. The report needs to be readable, with complete sentences and proper grammar. A report with too little information will not be useful, and a report that is filled with unnecessary information will often confuse the reader. Graphs and tables need to be properly labeled and referenced in the text. Numbers should always be shown with the appropriate units. Your report should be typed. Wordprocessors have equation editors and work well for reports. Most spreadsheet software does a decent job at graphing and making concise tables of data. Graphs can be exported from the Capstone software and inserted directly into the report.

The formal reports will be done after you collect data in class. Formal reports will be submitted to the TA at the next meeting of the lab section. Electronic submission (e-mail) of formal lab reports is not allowed unless explicitly approved by your TA. If electronic submission is allowed by the TA, it is the responsibility of the student to submit the report ontime and in the correct format. Late formal lab reports will receive a 10% deduction for each day or part of a day the report is late. Formal lab reports must be the work of

the individual student except for data collected and calculationd performed during the lab period. Group reports are not allowed.

The 30 points for the formal lab reports will be allocated as follows:

- Quiz - 4 points
- Introduction - 5 points
- Procedure - 4 points
- Data, Analysis, and Results - 11 points
- Conclusions - 6 points

The components of a formal lab report consist of the following.

- **Title:** The name of the lab should appear prominently at the top of the first page. Your name, the name of your lab partner, your TA, your lab section and the date should also be shown at the top of the first page.
- **Introduction:** In this section, you should describe the motivation for the experiment. The purpose of the lab should be clearly stated. All important concepts, physical principles, and laws should be clearly explained. Theoretical information should be clearly explained and its relevance to the experiment clearly defined.
- **Procedure:** The procedure section should contain a clear description of the experimental process. Information in this section should allow another group to reproduce the experiment after reading this section. Relevant equipment and apparatus should be listed in this section.
- **Data and Analysis:** This section should contain a clear presentation of the data obtained. This section should contain all of the raw data. The data should be well organized and clearly labeled. A table of data is usually a good idea. Graphs are highly encouraged and often required in many labs. Graphs should be neat, have a clear title and have all axes clearly labeled. Tables, figures, and graphs should be referenced in the text. All data should be included, even if you suspect it is in error. Also remember to label all graphs, and include units for all numbers listed. The manipulation and calculations of the data should be presented. One example of any calculation must be shown for any set of multiple data points. Other calculations should be neat and clearly explained. It is not necessary to show all arithmetic calculations but the reader should be able to clearly understand the manipulation of the raw data to determine the final results. This section should contain a discussion of uncertainties i.e., systematic and/or statistical errors as appropriate. This section is also the appropriate place to answer questions that are asked in the lab manual or additional questions that your TA might have for you.

- **Conclusions:** This is the section where you state whether or not you confirmed the principle being tested and present a thorough description of any relevant errors. Was the objective stated in the purpose section attained? If a physical parameter was measured, what is the value? How does the value compare to the accepted value? What is the 'uncertainty' in your value, e.g., percent error?